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ABSTRACT

A study examined the effects of sex, handedness, and instructions in the processing of verbal and spatial information presented tachistoscopically. Subjects, 48 volunteers from Illinois Benedictine College, were evenly distributed in terms of sex and handedness, and were further divided into two subgroups based on whether visual field attendance instructions were provided. In each test trial, subjects attended to a geometric figure placed in the middle of the tachistoscopic screen while a four-by-four matrix containing five strategically placed letters was presented in either the left or right visual field for a 100 millisecond duration. Mixed factorial analyses were employed to measure the number of letters and letter positions correctly recalled in each visual field, with sex (male, female), handedness (left, right), and experimental instructions (field attendance, non-attendance) representing the between-subject factors and target material (letters, positions) representing the within-subject factors. Retention analyses showed that dextral males demonstrated a right visual field (RVF) advantage for letters, and that instructions consistently contributed to more effective recall. It would appear that the attentional hypothesis is a more effective explanation of asymmetrical performance than cerebral differences. (A figure of the stimulus matrix used in the tachistoscopic experiment, and a table of the mean number correct letter responses in RVF as a function of sex, handedness, and instructions are included, and 45 references are appended.) (MM)

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Cerebral Asymmetries in the Processing of Tachistoscopic Information as a Function of Sex, Handedness, and Instructions

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Abstract

Based on previous asymmetrical findings with dichotic listening tasks, it was predicted that males would show a right visual field (RVF) advantage for recall of letters presented tachistoscopically and a left field advantage (LVF) for recall of letter positions. Subjects were evenly distributed in terms of sex and handedness, and were further subdivided based on whether visual field knowledge was provided beforehand. On each test trial, subjects attended to a geometric figure placed in the middle of the tachistoscopic screen while a 4 x 4 matrix containing five strategically placed letters were presented in either the left or right visual field for a 100 msec duration. Retention analyses showed that dextral males did in fact demonstrate a RVF advantage for letters, and that instructions consistently contributed to more effective recall. It would appear that the attentional hypothesis is a more effective explanation of asymmetrical performance than cerebral differences.

Cerebral Asymmetries in the Processing of Tachistoscopic Information as a Function of Sex, Handedness, and Instructions

Tachistoscopic studies have been employed in the past in order to determine if any hemispheric differences occur within subjects in their processing of visual materials. By means of an instrument referred to as the tachistoscope, information is typically exposed for 150 msec durations or less to either the subject's right visual field, left visual field or both fields simultaneously (i.e., a bilateral presentation). To more effectively control for random eye movements in each field, the subject is asked to fixate on a single stimulus occupying the central portion of the screen.

Similar to dichotic listening tasks, asymmetrical trends have been evidenced in the lierature, namely a right visual field (RVF) or left hemisphere advantage for words and letters and a left visual field (LVF) or right hemisphere superiority for nonlinguistic stimuli, ranging from sets of dots to human faces (Bryden, 1965; Ellis & Shepard, 1975; Kimura, 1966, 1969). Moreover, bilateral presentations have evoked even greater visual field differences, especially with

verbal materials (Bradshaw & Nettleton, 1983; Bryden, 1978).

In further confirmation of Levy (1972) and Harris' (1978) lateralization theories, many tachistoscopic experiments have obtained a noticeable sex effect, with males showing more pronounced asymmetries than females. More specifically, a LVF superiority trend was found in males for nonverbal materials (Berlucchi, Marzi, Rizzolatti, & Umilta, 1976; Davidoff, 1977; Kimura, 1969; Levy & Reid, 1976, 1978; McGlone & Davidson, 1973; Rizzolatti & Buchtel, 1977; Sasanuma & Kobayashi, 1978; Walter, Bryden, & Allard, 1976) and an occasional RVF preference for various types of verbal material (Bradshaw & Gates, 1978; Bradshaw, Gates, & Nettleton, 1977; Bryden, 1965; Hannay & Malone, 1976; Kail & Siegel, 1978; Levy & Reid, 1976; Marshall & Holmes, 1974). When handedness was examined in these tasks, sinistrals responded in a similar fashion to females, displaying on obvious field advantage (Bryden, 1964, 1965, 1973; Hardyck, 1977; Heller & Levy, 1981; Hines & Satz, 1971, 1974; McKeever & Gill, 1972; McKeever, Van Deventer, & Suberti, 1973; Orbach, 1967; Orlando, 1972; Zurif & Bryden, 1969).

Levy (1972) suggests that left-handed female subjects are at the greatest disadvantage when it comes to demonstrating spatial competencies due to their possessing a weaker lateralized organization for linguistic functions. A limited number of visual studies have shown this sex-hand interaction (Levy, 1976; McGlone & Davidson, 1973; Sanders, Wilson, & Vandenberg, 1982), thus implying that sinistral women might be inferior to dextral males in the processing of averbal (or spatial) inputs.

Though instructional manipulations of attention have influenced laterality in dichotic tasks along with sex (Iaccino & Sowa, 1988), it would appear that these experimental demands have no effect on asymmetries in specific visual assignments. Recent attention shifting studies conducted by Hardyck, Chiarello, Dronkers, and Simpson (1985) produced perplexing and contradictory trends to those previously observed by Bryden (1978). Instructions were manipulated similar to those in dichotic experiments, where subjects were told to attend strictly to one visual field and report if the items displayed were actual words or not by pressing the appropriate button. Throughout the Hardyck et al.

(1985) series of five studies, a consistent pattern emerged: the predicted RVF advantage was obtained for word recognitions, but instructions to bias subjects' attention to the right did not improve the overall accuracy of that field. Though these researchers concluded that visual field asymmetries in lexical decision tasks were not affected by attentional factors, more tachistoscopic experiments still need to be executed in order to more effectively determine if any performance differences are definitely due to differing cerebral organizations across subjects.

This experiment was an extension of the Kail and Siegel (1977, 1978) methodologies, in which sex and handedness effects were examined together in the processing of verbal and spatial information presented tachistoscopically. To further control for subject bias, specific instructions to attend to only one visual field were administered to the experimental groups. Our major hypotheses consisted of the following: 1) the strongest asymmetries would be evidenced in dextral males, with a RVF advantage for verbal material (i.e., letter recall) and an even more pronounced LVF advantage for spatial input (i.e., letter position

recall); 2) symmetries would be greatest in sinistral females with position recall being poorer than letter, in support of Levy's bilateral organization theory; and 3) that the attend instructions would not have a direct influence on males' asymmetrical performance nor produce any significant effect within the study, consistent with the Hardyck et al. (1985) trend.

Method

Subjects and Design

A group of 48 subjects from Illinois Benedictine College volunteered for this experiment, earning extra-credit points in courses for their participation. This group was evenly distributed in terms of sex and handedness, and was further divided into two subgroups based on whether visual field attendance instructions were provided. Mixed factorial analyses were subsequently employed to measure the number of letters and letter positions correctly recalled in each visual field, with sex (male, female), handedness (left, right), and experimental instructions (field attendance, non-attendance) representing the between-subject factors and target material (letters, positions) representing the within-subjects factor.

Handedness Assessment

Annett's (1967) 12-item handedness questionnaire was used to determine the hand dominance of an undergraduate pool of subjects selected from psychology and sociology classes. Only those with the strongest hand preference (as assessed by Nagae's criteria, 1983) participated in the tachistoscopic study. Each of the chosen groups' mean hand dominance is listed below: left-handed males = -10.32 (on a 0 to -12 sinistral scale with SD = 0.64), left-handed females = -10.84 (SD = 1.07), right-handed males = 10.97 (on a 0 to +12 dextral scale with SD = 1.23), and right-handed females = 10.58 (SD = 1.44).

Stimulus Materials and Apparatus

Similar to Kail and Siegel's (1978) materials, our thirty-six 5 x 5½ inch stimulus cards consisted of two parts that were shown simultaneously to subjects: one of three geometric figures (circle, star, or triangle) at the fixation point and a 4 x 4 matrix in either field.

Insert Figure 1 about here

Each matrix contained five letters that were randomly selected from the set of 20 consonants. These letters were placed in one of the 16 cells of each matrix, subject to the constraints that the letters only occur once in each matrix position, that the letters not be repeated on any stimulus card, that each row or column of the matrix contain no more than two letters, and that the letters not form a symmetric pattern within each matrix.

The purpose of placing a geometric figure at the fixation point was to insure that subjects focused on the center of each card and not randomly move their eyes to either field. The dimension of each figure was approximately .04 mm and the outer edge of each matrix was precisely .06 mm away from the fixation point, with letter size .04 mm and overall matrix size 2.00 mm. Approximate subject viewing distance from each stimulus card was 11.00 mm , and a Lafayette electro-tachistoscopic shutter with automated timer (Model No. 40010) regulated the duration of subjects' exposure to each card.

Response booklets consisted of two types of pages, depending on the target material to be recalled. If letters, the page contained the three geometric figures

arranged in a row, with all possible consonants arranged alphabetically in two rows directly below the figures, and subjects were simply told to circle the appropriate elements they had viewed. If letter position was tested, the page had an empty 4 x 4 matrix which appeared directly below the row of geometric figures, and subjects were required to place X's in the appropriate cells where they thought the consonants had been shown.

Procedure

On each of the 36 stimulus trials, subjects attended to a geometric figure in the middle of the screen while a matrix was simultaneously presented in either the subjects' left or right visual field for a 100 msec duration. Half the group (n = 24) was informed prior to each trial as to which field the matrix would be positioned, but they were still encouraged to fixate on the figure at the central location. Visual field placement of the letter matrices occurred in a counterbalanced order for both the instructed and uninstructed groups.

Retention of the matrix letters or letter positions immediately followed each tachistoscopic presentation. For each recall condition, two practice trials were

administered before the subjects were given the 16 test trials in an effort to acquaint them with the task requirements. These recall conditions were also presented in a counterbalanced order across groups. Subjects had an unlimited time to recall the matrix materials (though the maximum time range rarely exceeded 8.00 sec) and were encouraged to guess only if they felt unsure of their answers. The next test trial was initiated after each subject identified the five letters or letter positions within the previously shown matrix. The total number of correct subject responses under each recall condition was subsequently obtained and incorporated into the major field analyses.

Results

Letter Recall. With respect to matrix letter retention, the right visual field analysis revealed main effects of sex, handedness, and instructions, with F (1, 45) = 18.35, MSe = 1.86, $p < .01$; F (1, 45) = 9.63, MSe = 1.86, $p < .01$; and F (1, 45) = 12.48, MSe = 1.86, $p < .01$ respectively, as well as a Sex X Instructions interaction, F (1, 45) = 6.79, MSe = 1.54, $p < .05$. More importantly, a highly significant Sex X Hand X Instructions interaction was evidenced, F (1, 45) = 10.25,

MSe = 1.54, $p < .01$, which indicated a definite RVF advantage for dextral males under the attendance instructions.

Insert Table 1 about here

Scheffé post-hoc comparisons further showed that the male hand groups generally performed poorer without instructions, especially sinistrals (M = 7.67). As predicted, females demonstrated symmetrical performance across handedness as well as instructions.

When the left visual field analysis was performed, the only effect obtained involved experimental instructions, F (1, 45) = 12.30, MSe = 2.04, $p < .01$, with field knowledge contributing to more correct identifications. These surprising results did not confirm those of Hardyck et al. (1985); rather, they supported the Iaccino and Sowa (1988) dichotic trend.

Letter Position. Similarly, three-way visual field ANOVAs examined subject response differences in the recall of matrix letter positions. Consistent findings were the following: 1) an instructions effect in both

right and left fields, with F (1, 45) = 9.59, MSe = .67, $p < .01$ and F (1, 45) = 16.13, MSe = 1.32, $p < .01$ respectively, and 2) a Hand X Instructions interaction with informed dextrals identifying the most positions correctly (M = 14.54) and uninformed sinistrals the least (M = 10.03). The respective values were F (1, 45) = 6.33, MSe = 1.27, $p < .05$ and F (1, 45) = 13.81, MSe = 1.09, $p < .01$. Once again, experimental instructions had a beneficial effect on recall, as they did on letters. It should be pointed out that the hypothesized LVF advantage for dextral males did not occur with this particular type of input.

Discussion

To summarize the major findings, right-handed males showed a RVF advantage for printed inputs but did not demonstrate a LVF advantage for more spatially presented materials. Females, on the other hand, did not show a right or left visual field preference for either type of input, signifying that sex was as good a predictor of tachistoscopic performance (Bradshaw & Gates, 1978; Bryden, 1965; Kail & Siegel, 1977) as it was in dichotic listening (Iaccino & Sowa, 1988). Though handedness did contribute to many of the obtained effects,

field differences only occurred when the hand factor interacted with sex, once again raising doubts about the overall importance of this variable on laterality (see Nagae, 1985a, 1985b).

The failure to find a LVF advantage in males for spatial inputs did not support past results (Davidoff, 1977; Kimura, 1968; Levy & Reid, 1976, 1978), especially those (McGlone & Davidson, 1973; Sanders, Wilson, & Vandenberg, 1982) where sinistral female performance was significantly inferior to dextral male. This directly contradicts Levy's (1972) view that females have a poorer cerebral organization for nonverbal functions than males. Of course, other research like our own has not identified these predicted sex-hand interactions (Birkett, 1980; Johnson & Harley, 1980; Nagae, 1985b), and so more work definitely needs to be executed with these types of materials before one arrives at any inference regarding differences in brain functioning (i.e., cerebral asymmetries) across sexes and hand groups.

Based on our study, however, we can posit the direct influence of experimental instructions on tachistoscopic recall (unlike Hardyck et al., 1985).

Every major effect involved this factor, emphasizing the importance of experimental demands within these types of visual tasks. Looking at the laterality findings more closely, we see that dextral males performed better than any other group (M = 16.17) when they had foreknowledge that the information would be presented in the right visual field. Now this foreknowledge did not interfere with their focus on the target figure in the center of the screen. In fact, these males identified the most targets correctly (M = 15.00 with total number of targets = 16.00). The respective means of the other sex-hand groups were as follows: dextral females = 13.00, sinistral females = 12.33, and sinistral males = 10.50.

Obviously, right-handed males were approaching the letter recall task with a different attentional strategy. They followed the instructions to focus on the screen center and at the same time "primed" their RVF for the printed input that would be presented shortly. As Kinsbourne (1973, 1975) notes, the stimulus materials used in tasks might bias attention to the right or left, with verbal types priming subjects to fixate their gaze to the right automatically. It might

be that dextral males were employing this strategy while simultaneously following the demands of the task. That is, they were able to effectively distribute their attention from the directed center of the screen to their "biased" right field, and in this way were able to reduce the amount of information loss that would otherwise occur.

For position recall, however, this attentional division between target and field might have been too challenging for the sexes, and in fact it was; dextral male recall of targets and letter positions were similar to the other groups in both right as well as left visual fields. The only major effect with this type of input was with informed dextrals, but even here subjects could not bias their attention to a specific field as they could with letter recall per se.

We, therefore, suggest that attentional differences have more of an impact on laterality than varying cerebral organizations, and our conclusion would seem to be supported not only in particular tachistoscopic recall procedures but also in dichotic listening assignments (Iaccino & Sowa, 1988). It remains to be determined how we can implement this

research in other areas, particularly in the educational field. Perhaps the focus should be on the development of curricula which allow dextral male students to more effectively learn via the right side of the body. Effective use of audio-visual aids and age level of the student should definitely be considered when designing these new teaching techniques.

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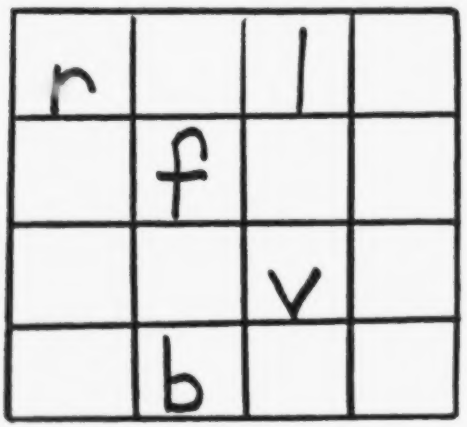
Figure 1

An Example of the Stimulus Matrix Used in the Tachistoscopic Experiment



Note. Dimension of the matrix has been enlarged three times.

Table 1

Mean Number Correct Letter Responses in Right Visual Field as a Function of Sex, Handedness, and Instructions

		Sex	
Hand		Males	Females
Left	Attend	11.23	12.17
	Not	7.67	10.00
Right	Attend	16.17	13.17
	Not	13.00	10.83

Note. Maximum possible number correct for right visual field = 80.00